

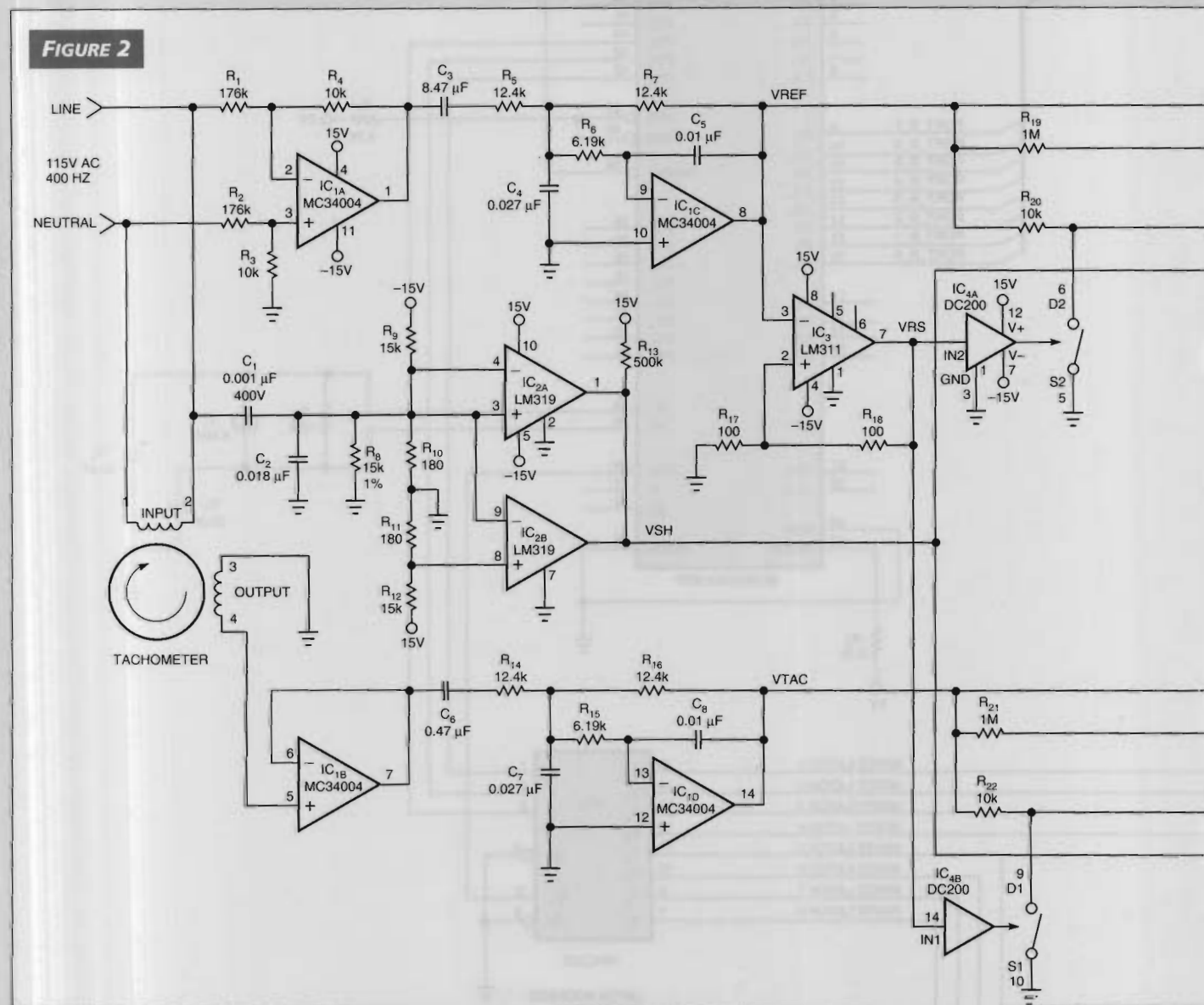
Tachometer demodulator has fast response time

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When a tachometer is a critical part of overspeed-shutdown circuitry, the response time of conventional demodulators may be too long. The circuit in the block diagram in **Figure 1** provides updated speed data. The circuit provides corrections for variations in excitation amplitude and frequency at every excitation half-cycle. The circuit is independent of processors and, therefore, immune to software- and bus-related failures.

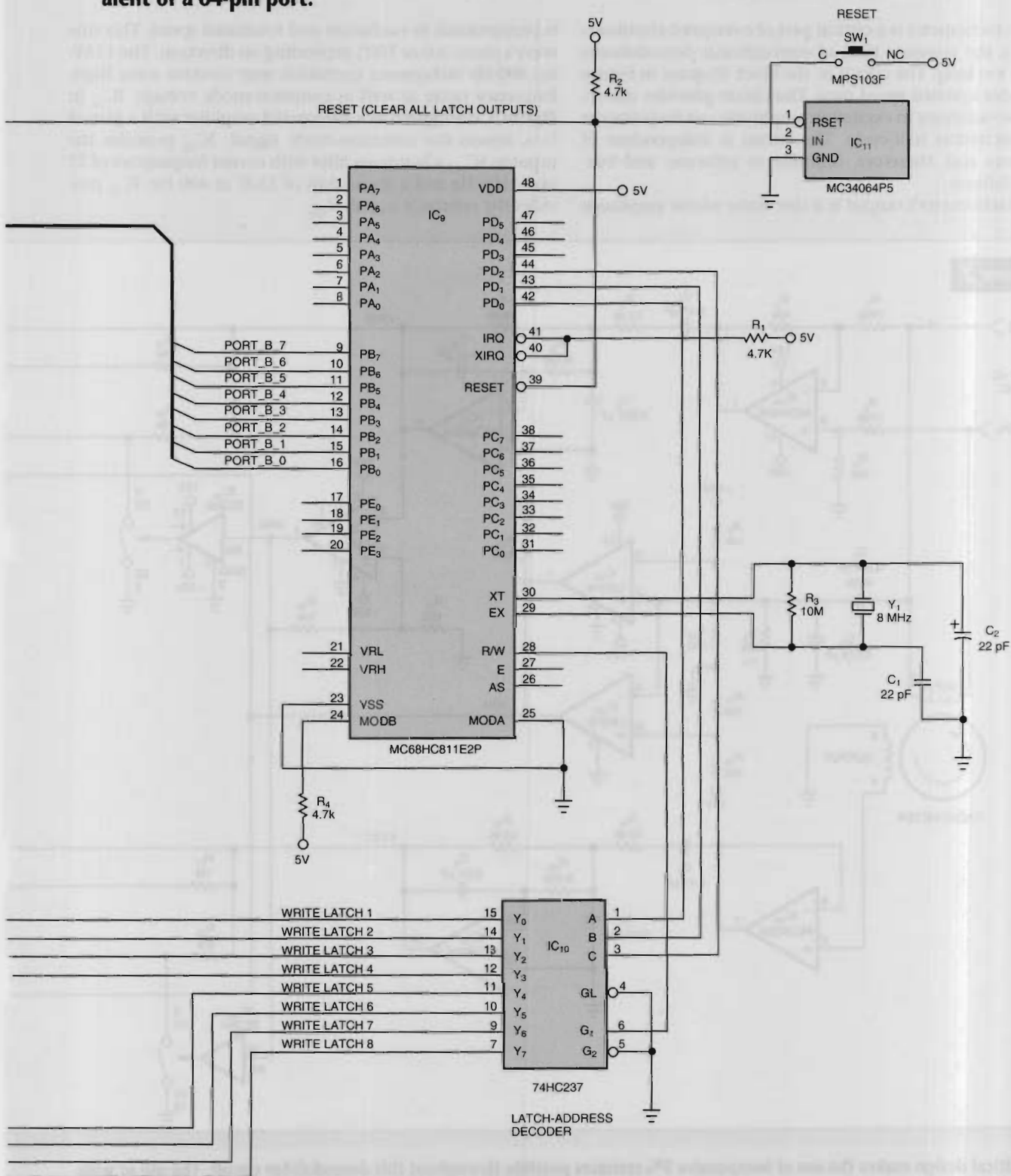
The tachometer's output is a sine wave whose amplitude

is proportional to excitation and rotational speed. This sine wave's phase is 0 or 180°, depending on direction. The 115V-ac, 400-Hz tachometer excitation may contain some high-frequency noise as well as common-mode voltage. IC_{1A} in **Figure 2**, configured as a differential amplifier with a gain of 1/17.6, rejects the common-mode signal. IC_{1A} provides the input to IC_{1C}, a bandpass filter with corner frequencies of 27 and 1100 Hz and a phase shift of 35.6° at 400 Hz. IC_{1C} provides the reference signal, V_{REF}.

FIGURE 2

A noncritical design makes the use of inexpensive 5% resistors possible throughout this demodulator circuit. The use of widely available ICs also helps keep the cost down.

Eight clocked latches expand the output of a 68HC11 μ C's eight-pin port to the equivalent of a 64-pin port.



IC_{1B} buffers the tachometer's output and drives IC_{1D}, a bandpass filter that matches the IC_{1C} filter. The output of IC_{1D} is the tachometer signal V_{TAC}. The excitation signal, attenuated by 1/44.5 and phase-shifted by 54.4°, drives the window comparator comprising IC_{2A} and IC_{2B}. The comparator's output, V_{SH}, is a 10-μsec-wide pulse that coincides

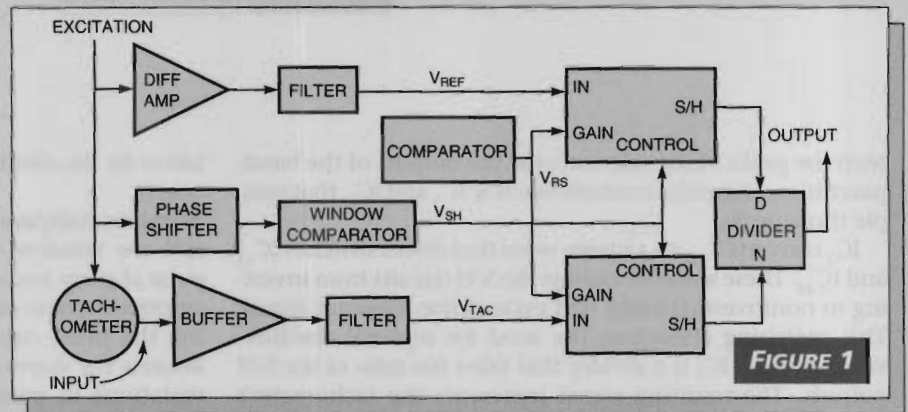
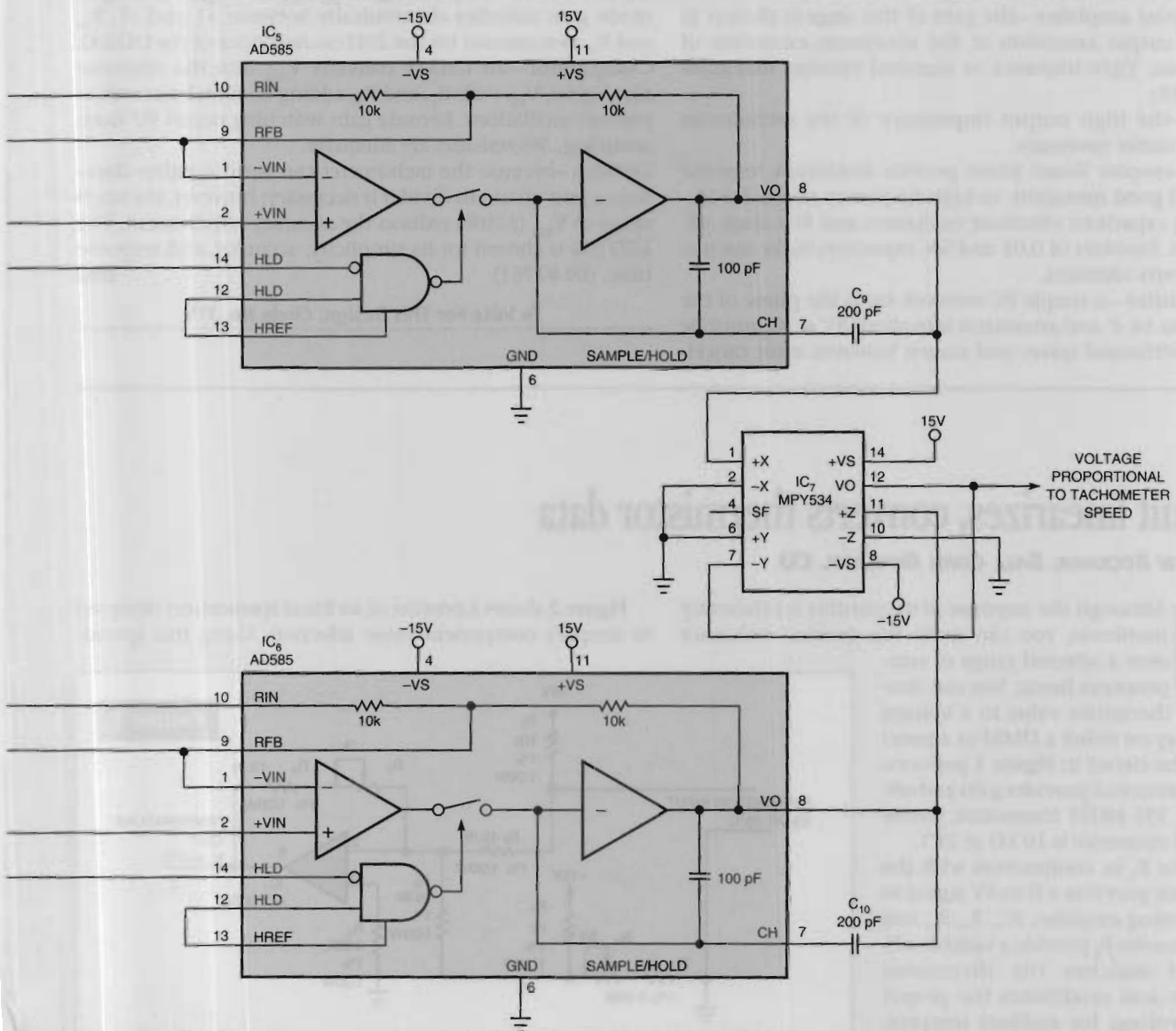


FIGURE 1
A small number of inexpensive circuit blocks configures a fast-response tachometer demodulator that rejects variations in excitation amplitude and frequency.



with the peaks of the sine waves at the outputs of the band-pass filters. This pulse controls two ICs, IC₅ and IC₆, that sample those peaks.

IC₃ converts V_{REF} to a square wave that drives switches IC_{4A} and IC_{4B}. These switches change the S/H circuits from inverting to noninverting every half cycle of the reference signal. This switching eliminates the need for separate absolute-value circuits. IC₇ is a divider that takes the ratio of the S/H outputs. The resulting signal represents the tachometer's shaft speed, corrected for variations in excitation frequency and amplitude. The response time of the circuit is less than 2 msec. The following are some design considerations for the demodulator:

Differential amplifier—the gain of this stage is chosen to prevent output saturation at the maximum excitation of 176V peak. Tight-tolerance or matched resistors maximize the CMRR.

Buffer—the high output impedance of the tachometer makes a buffer necessary.

Filters—lowpass Bessel filters provide minimum response time and good immunity to high-frequency noise. The dc-blocking capacitors eliminate excitation and first-stage offset errors. Resistors of 0.01 and 5% capacitors make the two filters nearly identical.

Phase shifter—a simple RC network shifts the phase of the excitation 54.4° and attenuates it to about 3V ac. C₁ must be able to withstand spikes and surges; however, error cancel-

lation by the divider makes 5%-tolerance components adequate.

Window comparator—with comparison points set at ± 100 mV, the window comparator provides a 10- μ sec positive pulse at every zero-crossing of the phase shifter's output. The combined phase of the filters and phase shifter is 90°, making the pulse coincide with the peaks of V_{REF} and V_{TAC} . Because the slope of a sine wave is very small near the peak, variations in pulse width and location cause negligible errors. The comparator resistors, therefore, need no tighter than 5% tolerance.

S/H—the AD585 is chosen for its speed and differential input. With the help of IC_{4A}, IC_{4B}, R₂₀, and R₂₂, the sample-mode gain switches electronically between +1 and -1. R₁₉ and R₂₁ compensate for the 25 Ω on-resistance of the DG200.

Comparator—an LM311 converts V_{REF} into the reference sign signal, V_{RS} , with R₁₇ and R₁₈ adding enough hysteresis to prevent oscillations. Because gain switching occurs 90° from sampling, 5% resistors are adequate.

Divider—because the tachometer can turn in either direction, a two-quadrant divider is necessary; however, the small range of V_{REF} ($\pm 20\%$) reduces the accuracy requirement. The MPY534 is chosen for its simplicity, accuracy, and response time. (DI #1761)

EDN

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Circuit linearizes, converts thermistor data

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Although the response of thermistors is inherently nonlinear, you can make the devices' resistance over a selected range of temperatures linear. You can convert the thermistor value to a voltage for display on either a DMM or a panel meter. The circuit in Figure 1 performs linearization and provides gain and offset for a YSI 44031 thermistor, whose nominal resistance is 10 k Ω at 25°C.

Resistor R₁ in conjunction with the thermistor provides a 0 to 5V signal to the summing amplifier, IC₁. R₇, R₉, and potentiometer R₈ provide a variable offset that matches the thermistor response and establishes the proper output voltage for ambient temperature. Resistor R₄ and potentiometer R₃ provide variable gain that also matches the thermistor response.

Figure 2 shows a portion of an Excel spreadsheet designed to simplify component-value selection. Using this spread-

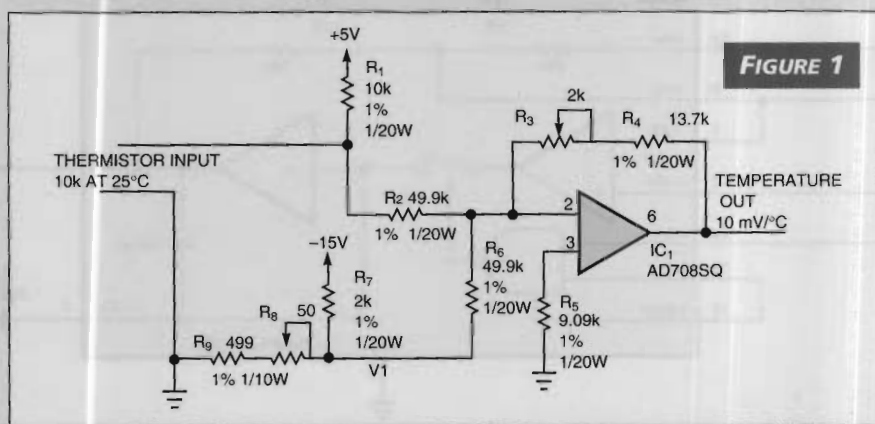


FIGURE 1

Using a handful of resistors, an op amp, and a spreadsheet, you can make the temperature response of highly nonlinear thermistors linear.

sheet, you can enter thermistor values and modify the offset- and gain-resistor values to achieve the desired circuit response. You can find the spreadsheet, named THRM-BIAS.XLS, in the compressed ZIP file attached to EDN BBS /DI_SIG#1763. The ZIP file also contains associated Excel-based graphs (with extension .XLC) illustrating the linearization performance.

The circuit in Figure 1 demonstrates accuracy within 1°C over 0 to 50°C and within 5°C over -20 to +80°C. The accuracy and range you achieve depend on the characteristics of the thermistor you choose and on your selection of the appropriate resistor values.

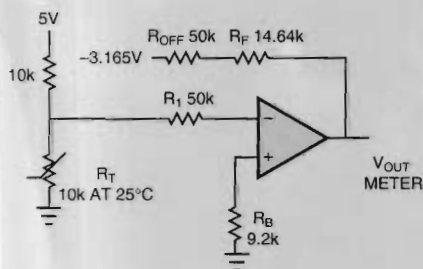
To calibrate the circuit, first adjust potentiometer R_8 to achieve the required offset voltage from the spreadsheet at V_i . Then, apply a known resistor at the thermistor input and adjust potentiometer R_3 for the proper output (gain). Finally, connect the op amp's output to a DMM or to a voltage-input panel meter with a selectable decimal point. A $\pm 2V$ meter displays temperatures from -199.9 to +199.9°C, which is more than adequate for many applications. (DI #1763)

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FIGURE 2

V_{source}	5.00V
R_{pu}	10,000 Ω
R_1	50,000 Ω
R_f	14,640 Ω
R_{off}	50,000 Ω
V_{off}	-3.165V
A_{mp}	29.28 V_o/V_i



Temp	RT (Ω)	V (Rt)	dV/dt	T _{out}	Error
-80	3,558,000	4.157		-29.04	
-75	2,440,000	4.152	0.001	-28.91	
-70	1,694,000	4.146	0.001	-28.73	
-65	1,190,000	4.138	0.002	-28.48	
-60	845,900	4.126	0.002	-28.14	
-55	607,800	4.110	0.003	-27.68	
-50	441,300	4.089	0.004	-27.07	
-45	323,700	4.062	0.005	-26.27	
-40	239,800	4.027	0.007	-25.23	
-35	179,200	3.982	0.009	-23.91	
-30	135,200	3.925	0.011	-22.25	
-25	102,900	3.855	0.014	-20.19	4.81
-20	78,910	3.769	0.017	-17.68	2.32
-15	61,020	3.666	0.021	-14.67	0.33
-10	47,540	3.545	0.024	-11.13	-1.13
-5	37,310	3.406	0.028	-7.05	-2.05
0	29,490	3.249	0.031	-2.45	-2.45
5	23,460	3.075	0.035	2.65	-2.35
10	18,790	2.887	0.038	8.15	-1.85
15	15,130	2.687	0.040	14.00	-1.00
20	12,260	2.481	0.041	20.04	0.04
25	10,000	2.273	0.042	26.13	1.13
30	8194	2.066	0.041	32.19	2.19
35	6752	1.865	0.040	38.07	3.07
40	5592	1.673	0.038	43.68	3.68
45	4655	1.493	0.036	48.95	3.95
50	3893	1.327	0.033	53.83	3.83
55	3270	1.174	0.030	58.29	3.29
60	2760	1.037	0.028	62.32	2.32
65	2339	0.913	0.025	65.93	0.93
70	1990	0.803	0.022	69.15	-0.85
75	1700	0.706	0.019	72.00	-3.00
80	1458	0.620	0.017	74.50	-5.50
85	1255	0.545	0.015	76.70	
90	1084	0.480	0.013	78.63	

An Excel spreadsheet allows you to play with various thermistors. You enter the thermistor value and adjust the offset- and gain-resistor values to achieve the desired circuit response.